Modeling Affective State using Learning Vector Quantization

Gert-Jan de Vries

Cover design The cover design was created by composition of the learning dynamics of 3 by 2 by 3 RSLVQ prototypes on a simulated dataset consisting of 3 classes, where two classes (orange and green) are represented each by a single Gaussian cluster and a third class (blue) by a mixture of two smaller Gaussian clusters. Overlayed are mannequin-shaped heatmaps that indicate the location at which people feel the following emotions within their body (pairwise top,bottom): Happiness, Love (orange); Surprise, Envy (blue); Pride, Anger (green). The green representations were created by exchanging the red and green color channels. The six mannequins were taken from Nummenmaa et al. (2013) and printed with permission of Prof. Nummenmaa.

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Inhoudsopgave

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The context in which I performed my PhD research, was next to a full time job. To complicate matters further, in 2011 I moved within Philips Research to a completely new domain: Healthcare, more specifically readmission management for chronically ill patients. The job of analyzing clinical data posed yet another multidisciplinary challenge, which I enjoyed exploring with Aleksandra Tesanovic and Gijs Geleijnse. Combining all activities was far from easy and from time to time I seriously considered stopping my PhD. I want to thank Aleksandra, Gijs, Igor Berezhnoy and Marjolein van der Zwaag for their support in providing motivation to continue and maintain the right focus to bring this endeavour to a good end. Aleksandra, a very special thanks to you for your trust in me being able to handle the challenges in parallel, for letting me be part of your team and supporting me throughout. Igor, thanks for relentlessly 'bugging' me and for your unique and humorous support to not let me quit. Thank you, Jon Mason, for helping out with the cover design. Ioanna Sokoreli and Marjolein, thank you for being my paranymphs and for your support in the final stage of the project.

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Abbreviations and Symbols

Nomenclature

$\xi_\sigma \in \mathbb{R}^d, y_\sigma$	d-dimensional input sample indexed by σ, representing class y_σ
y	label of input sample
$\mathbf{w}_S \in \mathbb{R}^d, c_S$	d-dimensional prototype indexed by S, representing class c_S
d_S	Euclidian distance between a sample ξ and prototype $\mathbf{w}_S$
N_c	number of classes
ϵ_g	generalization error

Acronyms

Psycho-physiology

ANS	Autonomous Nervous System
BP	Blood Pressure
BVP	Blood Volume Pulse
CNS	Central Nervous System
CPM	Component Process Model
ECG	Electrocardiogram
EDA	Electrodermal Activity
EEG	Electroencephalogram
EMG	Electromyogram
fMRI	functional Magnetic Resonance Imaging

GSR	Galvanic Skin Response
HF	High Frequency
HRV	Heart Rate Variability
IBI	Inter-Beat Interval
LF	Low Frequency
MRI	Magnetic Resonance Imaging
PAD	Pleasure, Arousal, Dominance
PNN50	Proportion of Inter-Beat Intervals (IBIs) > 50 ms
PNS	Peripheral Nervous System
PPG	Photoplethysmography
PSNS	Parasympathetic Nervous System
RMSSD	Root Mean Square of Successive Differences
RSA	Respiratory Sinus Arrhythmia
RSP	Respiration
SA	sinoatrial
SC	Skin Conductance
SCL	Skin Conductance Level
SCR	Skin Conductance Response
SDNN	Standard Deviation of IBIs
SDSD	Standard Deviation of Successive Differences
SNS	Sympathetic Nervous System
ST	Skin Temperature
VAD	Valence, Arousal, Dominance
VHF	Very High Frequency
VLF	Very Low Frequency

Machine learning

ANFIS	Adaptive Neuro-Fuzzy Inference System
ANN	Artificial Neural Network
ANOVA	Analysis of Variance
ARMA	Autoregressive-Moving Average
AUC	Area Under the Curve
BLD	Best Linear Decision
BN	Bayesian Network
DT	Decision Tree
FDA	Fisher Discriminant Analysis
GLVQ	Generalized Learning Vector Quantization

GMLVQ	Generalized Matrix Learning Vector Quantization
GRLVQ	Generalized Relevance Learning Vector Quantization
HMM	Hidden Markov Model
KFDA	Kernel Fisher Discriminant Analysis
KLDA	Kernel Linear Discriminant Analysis
kNN	k-Nearest Neighbors
KPCA	Kernel Principal Component Analysis
LDA	Linear Discriminant Analysis
LFM	Learning From Mistakes
LFM-W	Learning From Mistakes with a window
LVQ	Learning Vector Quantization
MRSLVQ	Matrix Robust Soft Learning Vector Quantization
NBN	Naive Bayesian Network
NKFDA	Non-linear Kernel Fisher Discriminant Analysis
NLP	Natural Language Processing
ODE	Ordinary Differential Equations
PCA	Principal Component Analysis
PNN	Probabilistic Neural Network
QDC	Quadratic Discriminant Classifier
RBF	Radial Basis Function
RF	Random Forest
ROC	Receiver Operating Characteristic
RSLVQ	Robust Soft Learning Vector Quantization
RT	Regression Tree
SVC	Support Vector Classifier
SVM	Support Vector Machine
VQ	Vector Quantization

Image processing

AU	Action Unit
FACS	Facial Action Coding System
HLAC	Higher-order Local Autocorrelation
HLACLF	HLAC-like features
LBP	Local Binary Patterns
LDP	Local Directional Patterns
SIFT	Scale-Invariant Feature Transform